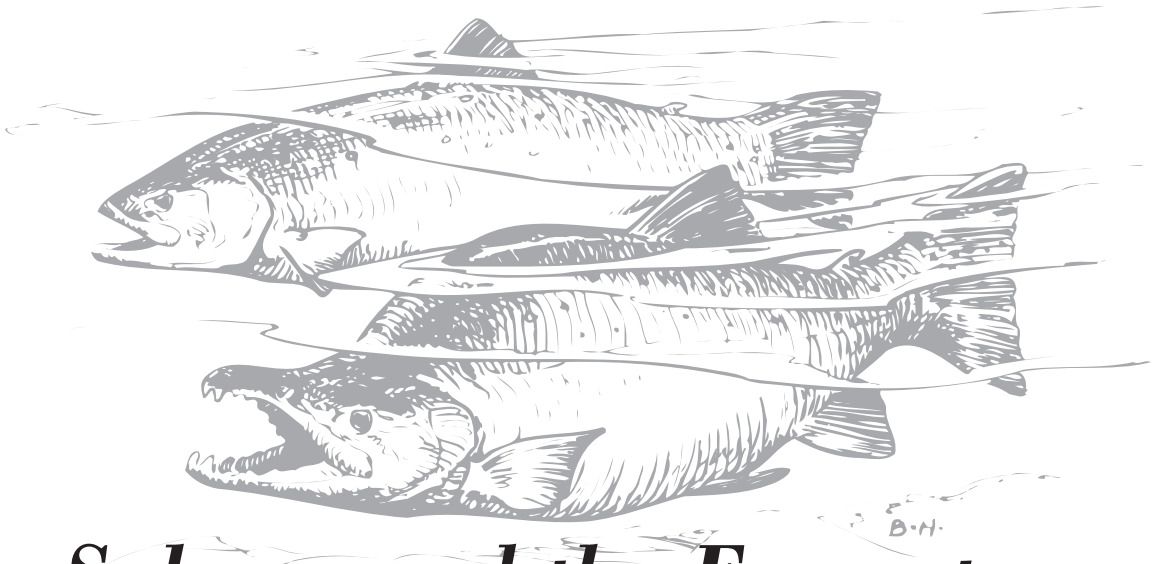
SPLASH!
Stormwater Pollution: Learn and Share

A Local Water Quality Curriculum

City of Eugene
Stormwater Management Program



Salmon and the Ecosystem:
A Curriculum for Grades Five through Eight

Developed and written by:
Sally Markos, City of Eugene Public Works

Reviewed by:
Angie Ruzicka, Science Coordinator,
4J School District

EUGENE

Public Works
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Lesson 1:

An Ecosystem Out of Balance

Salmon in the Pacific Northwest

Objective: This unit explores the complex role salmon play in the Pacific Northwest ecosystem, the factors that have contributed to the decline of salmon populations, and the impact of losing a species that is key to the health of the entire ecosystem. The unit was written to be used with the fourth and fifth grade Ecosystems science kit and as an extension to the sixth through eigth grade Splash! units.

Teacher Background

What Is a Keystone Species?

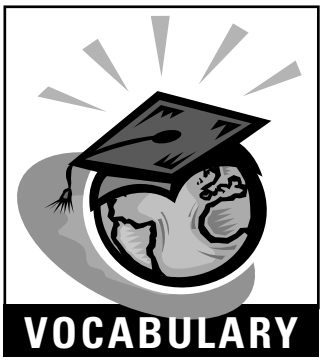
A keystone species is a species whose presence contributes to a diversity of life and whose extinction would consequently lead to the extinction of other forms of life. Keystone species help to support the ecosystem (entire community of life) of which they are a part.

Older than the Ice Ages

Wild salmon are a **keystone species** in the Pacific Northwest. The health of salmon populations in the Pacific Northwest is a reflection of the health of our rivers and ecosystems.

The ecosystem in the Pacific Northwest evolved around the plentiful salmon runs that have occurred since before the Ice Ages. Salmon have survived for millions of years; enduring mud flows caused by volcanic eruptions and ice sheets that covered the region during the Ice Ages. The salmon's life cycle evolved as they adapted to periods of ice and water in the nutrient-poor freshwater streams in the Pacific Northwest. The lack of nutrients in the streams where salmon hatch was an important factor in the evolution of the salmon's migration to the ocean. While freshwater streams provide ideal habitat for spawning and the growth of juvenile salmon, the ocean provides the rich food and nutrients adult salmon need to grow. For millions of years, people, other animals and the forests have depended on salmon as a food source rich with nutrients brought back with them from the ocean.

Wild salmon are an **anadromous** fish; born in freshwater, migrating to the saltwater ocean and then returning to their home stream to spawn. In their life cycle, freshwater habitats are used for spawning, incubation



Write the following vocabulary words on the board for students to copy. Assign students to write a sentence containing each word. Be sure the sentences make a reference to salmon.

keystone species
anadromous
spawn
estuary
nutrient
biomass
endangered
extinct
stock
riparian
pesticide
olfactory

and the rearing of juvenile fish. During the juvenile phase, the salmon migrate to estuaries along the ocean where they make the adjustment between fresh and salt water. After a period of time in the estuaries, young adult salmon head to the ocean where they feed on a rich diet of invertebrates and fish. The marine-derived nutrients salmon accumulate in the ocean play a valuable role in sustaining the Pacific Northwest ecosystem and in salmon survival.

Long Ago: A Perfect Balance

Over 100 years ago, salmon were plentiful in The Pacific Northwest. Stories were told of salmon runs on the Columbia River being so large people could walk across the river on the backs of the salmon! The salmon runs went far inland to rivers and streams in Washington, Oregon, Idaho and California. At that time, the estimated biomass of salmon returning each year was almost 500 million pounds. Spawning salmon returning from the ocean provided food for many bird, reptile, amphibian species, and native people. The salmon also had a large role in the ecosystem even after dying: their decaying bodies fertilized trees and plants along the shores of streams, provided nutrients to aquatic organisms, and perpetuated the species by being a food source for newly hatched salmon. Bears, bald eagles, wolves and other animals that fed on salmon dragged salmon carcasses into the forest, further spreading nutrients to the land. Native Americans also took salmon from the streams to the forests and sometimes traded dried salmon to tribes on the other side of the continental divide, further spreading the biomass. The constant recycling of nutrients, with salmon bringing important nutrients from the distant ocean to the forest, kept the ecosystem healthy and in balance.

The Beginning of the Decline

In the late 1800's, people living in the Pacific Northwest began harvesting salmon commercially. Salmon canneries sprung up on the Columbia River. Millions of pounds of salmon were caught yearly and canned between the 1860's and 1930. After 1930, salmon numbers began to decline and continue to decline today. The building of hydroelectric dams also contributed to the decline in populations by blocking the routes to traditional spawning grounds. Overfishing, habitat destruction, water pollution, elevated water temperatures, erosion and many other factors have reduced salmon numbers even more. Today, 27 stocks of salmon are extinct and over 100 stocks of salmon are at high risk of extinction. Almost 100 more stocks of salmon are in danger.

Until recently, the decline in salmon runs and loss of stocks has been only viewed as an economic loss for the fishing industry. The ecological significance of salmon in the ecosystem was not considered a factor.

Scientists now recognize salmon play a key role in delivering nutrients to streams and rivers throughout the Pacific Northwest. Studies of historical salmon runs have determined that the total biomass of salmon returning from the ocean to spawn was 320 to 500 million pounds. Because of the sharp decline in salmon populations, it is estimated that only 3%-7% of the once plentiful marine-derived biomass is being delivered by salmon to rivers and streams in the Pacific Northwest. This loss of biomass affects the entire ecosystem and also has dire consequences in the salmon populations. Because juvenile salmon depend on the nutrients from the rotting carcasses of the adult salmon for survival, the reduction in numbers of returning adult salmon mean fewer juveniles survive to make the journey to the ocean to continue the cycle. With reduced food supplies, those that do survive are often smaller. The reduction of salmon runs also impacts the populations of small aquatic organisms that feed on the decaying carcasses. This further reduces food sources available for young salmon and other species that depend on aquatic invertebrates during their juvenile phases.

The loss of biomass also has an impact on predator species. In the Pacific Northwest, approximately 135 species of terrestrial and marine mammals, birds, reptiles and amphibians have a direct or indirect relationship with salmon. Nine species have a very strong link to salmon. Black bears, grizzly bears, killer whales, river otters, Caspian terns, common mergansers, harlequin ducks and osprey are all major salmon eaters. The loss of salmon greatly reduces the food source they need for survival.

Salmon need forests...and forests need salmon!

Just as the forests depend on migrating salmon to deliver nutrients from the ocean, salmon depend on forests for the habitat they need to survive.

The riparian areas along mountain streams are as lush and green as a well-kept garden. We all know that to keep our gardens healthy and growing we need to feed the plants. Since mountain streams contain few nutrients, how do the plants stay lush and green? *Salmon* provide a natural fertilizer for the forests. Salmon that return to their native streams die soon after spawning. Their bodies are washed by stream currents to the shore, where they decay. The rich nutrients carried back from the ocean in muscle and bones are washed by rainwater into the soil. The nutrients are absorbed by the roots and distributed throughout the entire plant. (See handout, *Salmon and Sitka Spruce: A Mutually Dependent Relationship*)

Birds and animals also play a part in helping carry these nutrients deeper into the forests. Birds and bears carry salmon

What is a stock?

Each species of salmon is made up of many *stocks*, or subgroups of species (sometimes called a *race*). Salmon that belong to different stocks can interbreed, but usually do not because of geographic or seasonal barriers. They migrate to different streams to spawn, or spawn in the same river in different seasons. Each stock represents a slightly different genetic makeup of fish, and the greater number of stocks therefore, the greater genetic diversity for each salmon species-an important feature for adapting to environmental changes and ensuring the future of that species.

carcasses far inland from streams. The parts of the salmon they don't eat are left to decay on the forest floor and provide natural fertilizer for surrounding plants. The nutrients are also deposited with bird and animal waste far from rivers and streams. Scientists have done studies to trace certain nutrients by identifying chemical elements unique to ocean food sources eaten by salmon. These elements have been found [hundreds of miles away from the ocean] in trees, leaves, and insects in areas where salmon spawn.

A closer look at the causes of salmon decline

Many factors have contributed to the decline in salmon populations in the Pacific Northwest. Massive overharvest, the construction of hydropower dams, poor logging and ranching practices, and polluted rivers have all contributed to the loss of salmon runs in the Pacific Northwest.

Eroded soil from construction sites is carried with rainwater into storm drains that lead directly to local waterways. Silt and dirt clog salmon spawning grounds and smother salmon eggs.

Overharvest

Overfishing has been a major factor in decimating salmon populations. In the early 1900's, canneries on the Columbia River processed millions of pounds of salmon. The salmon that made it past the purse seins and gillnets used by fishing boats in the ocean then faced fish traps placed in the rivers. Whatever salmon that remained were fished by Native Americans who lived along the river.

Hydropower Dams

Hydropower dams have had a major impact on salmon survival. Dams block upstream migration and many fish are sucked into the dam's powerful turbines and perish. To mitigate salmon losses, many dams have fish ladders that are constructed to allow the salmon safe passage. Although fish ladders help, they are not entirely effective in helping adult salmon make it back to their spawning areas.

Poor Land Management

Habitat destruction is another factor that has contributed to salmon's decline. Poorly managed livestock grazing, bad logging practices, and unprotected construction sites have increased the amount of runoff from the land to streams. Silt and dirt carried with runoff cover stream bottoms, smothering salmon eggs and embryos and destroying spawning areas.

A Modern Problem: Polluted Stormwater Runoff

At one time, industrial discharge and lack of sewage treatment in cities were the major causes of water pollution. The passage of environmental legislation and improved sewage treatment in our cities have both contributed to a dramatic reduction of industrial pollutants entering rivers and waterways. However, rivers are still being polluted in a way that is harder to detect. Rivers are being polluted by "non-point source pollution," or pollution that does not come from one specific, identifiable location. Stormwater runoff from agricultural areas and cities is now the major source of pollution in our waterways.

What is stormwater runoff? Our modified landscape now includes roads, parking lots, and buildings that have replaced natural vegetation. Any surface that prevents rainwater and snowmelt from percolating into the ground is called an "impervious surface." Rainwater or snowmelt that runs across these impervious surfaces is called "stormwater." Any time it rains, oil, dirt, metals, and chemicals are carried with stormwater into local waterways. In many cities, stormwater is not treated or filtered before entering streams and rivers.

What's in Stormwater?

The pollutants carried along with stormwater combine to become a toxic mix that enter our rivers. Spilled paint, oil slicks and garbage are some of the "visible" pollutants we commonly see. However, many pollutants are not visible once they enter a waterway. These invisible pollutants are just as harmful as those we can see.

A Toxic Mix

Fertilizers and pesticides used in yards, gardens and in farm fields are major pollutants that harm fish and other aquatic organisms and destroy habitat. Developed to harm or kill living organisms, pesticides (which include insecticides, herbicides, rodenticides and fungicides) continue to work once they enter streams and rivers.

Pesticides have been identified as a major pollutant that affect the salmon life cycle and salmon survival. Pesticides can cause behavioral changes in salmon, harm their reproductive systems and impair migration. Indirectly, pesticides cause harm to salmon by killing insects and other food sources along with changing the aquatic environment.

Many pesticides have been identified as directly or indirectly harmful to salmon. The Environmental Protection Agency lists approximately 36 pesticides commonly used in Oregon that have been found to harm fish (Lind, P. 2002). Many rivers, including the Willamette, contain some of these pesticides at or above levels known to harm fish.

Toxic Metals

A Seattle Post-Intelligencer story from April 14, 2003 reported a coho salmon kill-off in a creek that receives stormwater runoff from Sea-Tac airport. The deaths occurred during fall, coinciding with the start of seasonal rains. According to the story, residents had expressed concern about stormwater pollution from airport runways and maintenance areas entering local creeks.

The Washington State Department of Ecology has estimated that more than 803 million gallons of stormwater runoff comes from the airport each year. The most contaminated runoff (about 300 million gallons) is treated; the rest runs into holding ponds and is later released into two local creeks. Water samples taken from the creeks revealed extremely high levels copper and zinc. Copper has been identified as highly toxic to salmonids and even more toxic when combined in water with zinc and other metals (Environmental Contaminants Encyclopedia, National Park Service, 1997).

Although the exact cause of the fish kill-off has not been determined, the state Department of Fish and Wildlife concluded that exposure to chemicals was probably a factor in the deaths.

Something to think about:
Salmon are often compared to the canary in the coal mine. What significance does this analogy have in the Pacific Northwest?

As an example, Diazinon, a neurotoxic insecticide commonly used on lawns, golf courses, and in homes, is harmful to salmon exposed to even very small doses. (Although production of diazinon will be stopped in 2004, the chemical may be sold until all remaining stock is gone.) The Environmental Protection Agency has estimated that over 13 million pounds of diazinon are applied in the United States every year. Diazinon has been found throughout the United States in rivers, groundwater, rain, and fog. Studies have discovered that small, nonlethal doses of diazinon inhibits the salmon's sense of smell (Scholz, Truelove, et.al. 2000). Salmon depend on their sense of smell to detect predators and use olfactory cues to migrate back to their home streams to spawn. Exposure to diazinon makes salmon easy targets for predators and disrupts their journey back to their home stream to spawn.

Stormwater runoff causes pollution "pulses" directly after a heavy rainfall. Depending on the length and intensity of the rainy period, these pulses can last for one day or up to a few weeks. Stormwater is especially laden with oil, chemicals and debris when they occur after a dry period with no rainfall. An example of how deadly these pulses of pollution can be was demonstrated by a recent event in the Seattle area.

Since 1999, coho salmon migrating into streams in urban areas near Seattle have experienced unusual and sudden die-offs before spawning. Coho salmon, the first fish to migrate up the urban streams to spawn in the fall, were seen swimming erratically. Many of the salmon died before spawning. Since the erratic behavior and sudden death of the salmon coincides with the first fall rains, scientists believe the deaths are a direct result of the "first flush" of polluted stormwater runoff. (Runoff from the first fall rains is often the most toxic as it carries a summer's worth of accumulated pollutants into the storm drain system.) This is one of the first times polluted stormwater has been implicated as the direct cause of sudden salmon deaths.

Other Pollutants

Automobiles and trucks also contribute to stormwater pollution. Leaking automotive fluids, metals from deteriorating parts, and vehicle exhaust all make their way with rainwater into the storm system. Paint, solvents, dirt, garbage and pet waste are other common pollutants.

Water Temperature

Water temperature is also a critical factor influencing the salmon life cycle. Salmon need cool water for survival. High water temperatures can make salmon susceptible to disease and affect migration and spawning. It may not be obvious, but the temperatures in streams and rivers can be influenced by

stormwater runoff. Streets and parking lots not shaded by trees become superheated when the sun is out and can have a significant impact on nearby waterways. This is especially a problem in the spring and fall when showers are interrupted by sun breaks. The loss of trees along streams and rivers also exposes the water to the heat of the sun.

What Can We Do to Help Salmon?

Debates over fishing quotas, breaching dams, logging, and ranching practices have gone on for years. Since these issues involve government policy and regulations, it will be a long time before solutions are found for some of these problems. While these issues are being debated, individuals can focus on water quality and what they can do to keep water clean.

The choices we make in our every day lives can have an impact on water quality and the chances for salmon's survival. Unlike some other forms of pollution, stormwater pollution can be prevented by changing our behaviors. How we maintain our cars, care for our yards, deal with construction sites, and even clean up after our pets can make the difference betwee- having clean or polluted waterways.

Can the bridge be fixed?

The role of salmon in the Pacific Northwest ecosystem is much greater than we realize. The salmon function as a bridge between ocean and forest ecosystems that are separated by a great distance. The loss of salmon in the Pacific Northwest weakens that bridge and continued losses could eventually cause an ecosystem failure.

Already, studies have indicated some of the stream ecosystems in the Northwest may be destined for an ecosystem failure due to the diminished salmon runs. Where do we start to fix what has taken generations to destroy? Is it too late to repair the damage that has been done?

Exercises and Activities:

Activity 1: *Salmon Sentences*. Copy and distribute Activity 1, Student Handouts A and B.

Activity 2: *Salmon Homing Instincts* (*Find Your Way Home)*. Follow directions on Teacher's Instructions, Activity 2.

Activity 3: *Salmon Survival: Choices and Consequences*. Follow directions in Teacher's Instructions, Activity 3. Copy and distribute Student handouts A, B, and C.

Activity 4: *Stormwater Pollution Match-up Game*. Follow directions included on Teacher's Instructions, Activity 4. (Game cards included.)

Activity 5: *Salmon and Sitka Spruce*. Copy and distribute Student Handout for Activity 5.

References

Lind, P. 2002. Poisoned waters: pesticide contamination of waters and solutions to protect pacific salmon. Eugene, OR

Scholz, Truelove, et.al. 2000. Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Onchorynchus tshawytscha*). Can. J. Fish Aquatic Science 57: 1911-1918.

Lesson 2:

Food Chains and Food Webs

The Salmon Connection

Teacher Background

All organisms within an ecosystem are part of a complex web of living things that use and convert energy to sustain life. Many factors, **biotic** (living) and **abiotic** (non-living), can affect the availability of energy and nutrients within an ecosystem.

What is a food chain?

The food chain is the passing of energy and nutrients from one organism to the next. Food chains are linear and can be simply described as "who eats what." Since species interact within an ecosystem, and many animals eat more than one thing, food chains weave together to form more complex food webs.

An example of a simple aquatic food chain would be phytoplankton-zooplankton-squid-salmon-killer whale. Phytoplankton produce their own food by converting the energy of the sun into sugar through photosynthesis. This energy is passed along the food chain as zooplankton eat phytoplankton, squid eat zooplankton, and salmon feed on squid and other small fish before they begin their migration back to fresh water to spawn. Some salmon become food for killer whales. Ocean nutrients (nitrogen, phosphorus, carbon, etc.) also pass along the food chain and are deposited far upstream when salmon spawn and die.

That simple food chain becomes part of a food web when you factor in the other animals that eat salmon. Many species depend on salmon as a major food source, including bears, eagles, and river otters. Dead salmon are also a source of nutrients for small aquatic invertebrates in fresh water streams. The food chains of all of these species interweave with the salmon's to form a more complex food web. Food webs can be very fragile and any catastrophic event that adversely impacts one major food source could cause the entire web to collapse. (See example of El Niño.)

Something to think about:

Ecosystems run on solar energy which is abundant, nonpolluting, constant, and everlasting.

Brainstorm: Has there ever been an event or time when the amount solar energy has been reduced in an ecosystem? If so, why and what was the result? (Hint: What theories exist regarding the disappearance of dinosaurs?)

Within an ecosystem, biotic and abiotic factors can influence the availability of energy and nutrients. With the help of students, use Discussion 1 to list biotic and abiotic elements that can affect the food chain. Create a list on the board, leaving room to add information from Discussion 2.

Discussion 1:

All environments consist of biotic (living) and abiotic (nonliving) elements. What are the abiotic and biotic factors in the salmon's environment and what natural phenomena can influence and/or change them?

Examples of abiotic factors and influences:

The ocean: sunlight, water temperature,
Influences: currents, El Niño
Rivers and streams: sunlight, water temperature, oxygen content, available minerals
Influences: streamside vegetation, streamflow, turbidity, pollution

Biotic factors:

Producers: Produce own food. *Example:* Phytoplankton make food for themselves by converting energy from the sun via photosynthesis. The energy flows up the food chain as one animal consumes the next.
Consumers: Feed on others. Primary: herbivores; secondary: carnivores and omnivores
Decomposers: Bacteria and fungi break down organic material.

Discussion 2:

Human activities can have a harmful affect on aquatic environments, disrupting the transfer of nutrients and energy through the food chain. Polluted runoff from paved areas degrades water quality and can directly harm fish and other aquatic organisms. As an example, pesticides can kill small aquatic organisms that are a major food source for fish. The reduced food source for fish results in smaller fish populations, which then affects the the consumers that eat fish. It is important to note the "domino effect" that occurs when a food chain becomes disrupted.

Question 1:

What human activities affect abiotic factors in an aquatic ecosystem?

Sun/shade: logging
Water temperature: Trees, paved streets (stormwater runnoff), industrial discharge from urban areas
Oxygen: algae blooms from polluted runoff (fertilizer)
Sediment and Turbidity: siltation from erosion
Stream flow: dams, floods, drought, diversion, filling

What human activities affect biotic factors in an aquatic ecosystem?

Producers: algae blooms from fertilizer runoff deplete

oxygen available for other aquatic organisms
Consumers: oil, pesticides, and other pollutants can kill primary and secondary consumers

Question 2:

Can abiotic factors influence biotic factors in an environment?

The El Niño phenomenom gives us a perfect example of how an abiotic factor (weather) can impact an ecosystem, causing a domino effect on the food chain in that ecosystem. How do these changes affect the food web? The example below relates how El Niño can influence two different ecosystems and the food chain of two species; one beneficially and one harmfully.

Example: Ocean currents and water temperature influenced by the El Niño phenomenom result in more or less food available in an ecosystem. In El Niño years, cooler waters increase the production of zooplankton during the spring in Alaska. The increased food supply enhances the survival rate of juvenile salmon, which results in abundant adults returning to spawn in the following years. The abundance of spawning salmon provides more food for eagles, bears and many other species. The entire food web benefits.

The opposite happens in California. The El Niño phenomenom brings warmer ocean currents from the tropics to the west coast of the United States. Plankton production is dramatically reduced in the warmer water. Sardines, squid, anchovies and other sea creatures that feed on plankton die off or move north to cooler water, leaving less food for adult seals and sea lions. As a result, adult seals and sea lions are forced to spend more time hunting for food and less time feeding their young. The lack of food from their mothers results in a dramatic die-off of their young, and in the span of a year or two, the die-off affects the entire population. Both of these examples show how one abiotic factor can influence an entire food web as individual species in the web become more plentiful or are reduced.

Activity 6: *The Salmon Food Chain and Food Web*. Follow Teacher's Instructions for Activity 6. Element and organism nametags are included.

Another definition...

food pyramid

A graphic representation showing all the energy and biomass contained in each trophic level of an ecosystem at any given time, moving from producers up the food web to top-level consumers.

Additional Resources

The following additional resources have been selected to supplement the salmon curriculum. For more resources related to stormwater education, please refer to the Additonal Resources section of the SPLASH! curriculum for grades K-8.

Websites

http://schoolcentral.com/Discussion/PacificSalmon/PS-Activites.htm

Kids can create a food web, learn salmon vocabulary, play the salmon I.D. game, and use math to save the ocean! The website also includes games, art, songs, and stories for kids. Kids can also upload their salmon stories and artwork for display on the web.

www.riversmart.com

Kids will learn to become "Riversmart" about things they do at home. Includes a "Riversmart" quiz and a list of things kids and their parents can do to help keep rivers clean.

www.nwf.org/keepthewildalive/salmon/

The National Wildlife Federation's salmon website has lots of information about the natural history of chinook salmon, and science facts about habitat, their life cycle, and threats they face.

http://splash.metrokc.gov/wlr/waterres/salmonch.htm

This website has the Salmon Challenge, a fun, interactive game that shows kids how their decisons affect salmon and the environment. Developed by King County, Washington. Suitable for grades 4-9.

www.inforain.org/maparchive/salmon_nation.htm

This site has wonderfully detailed, color-coded maps showing the status of salmon in the Pacific Northwest. The maps clearly illustrate the dilemma of disappearing salmon stocks.

www.mckenziewatershedcouncil.org/mckenzieatlas/chinook_map.htm

Developed by the McKenzie Watershed Council, this site contains a printable map of the McKenzie River showing the spawning areas of the spring chinook salmon. The map also shows dams and hatcheries.

http://eesc.orst.edu/salmon/human/default.html

This website explores the human and natural influences on the salmon life cycle and environment. Contains very specific information about Oregon. Good information for teachers and middle school students.

www.bpa.gov/power/pl/columbia/stories/Journey1.htm

Developed by the Bonneville Power Administration, this website tells the story of *Oncorhynchus*, a Pacific Northwest Salmon. The narrative follows the salmon through her entire life cycle, from freshwater to the ocean and back, and describes the perils she encounters along the way.

www.oregonlink.com/flyfishing/historicphotos/celiloplatforms.html

This website contains historic photos of Native Americans using traditional fishing methods and drying salmon.

www.salmon.room.net/

Salmon Room has information about salmon the life cycle and a live salmon cam.

http://wdfw.wa.gov/wildwatch/

Live wildlife cams from Washington state, including a salmon cam.

www.sunnywalter.com/Apn-Mammals-Salmon.html#Gov

This website contains links to salmon cams and government agencies.

www.wildsalmon.org

Geared toward older kids, this website focuses on wild salmon and river restoration.

www.nceas.ucsb.edu/nceas-web/kids/main_pages/faq.htm

Kids Do Ecology. This website answers the question "what is ecology?" Kids can find out about food webs, abiotic and biotic factors in an ecosystem, and how to become an ecologist.

www.ci.eugene.or.us/salmon/default.htm

The City of Eugene's salmon page has detailed information about spring Chinook salmon in the Willamette River and the Endangered Species Act.

Video

A Last Wild Salmon

A great educational video for students, *A Last Wild Salmon* shows the life cycle of the Pacific Northwest Salmon in great visual detail. This film has won a BCMPA Leo Award for Cinematography and was a finalist at the New York Film Festival. 1997. $24.99 Available from amazon.com.

The Great Age of Salmon and the PAF

This video brings to life a fascinating era in the history of commercial fishing at the last frontier. Featuring film footage dating back to 1926, and narrated by industry pioneer Stan Tarrant, *The Great Age of Salmon & the PAF* is the story of the early fishing industry in Alaska and the Pacific Northwest, and of the Pacific American Fisheries Company of Bellingham. 1996. $19.95 Available from amazon.com.

Last Chance for the Pacific Salmon

A call to action by Trout Unlimited and The Wilderness Society to improve forest management for the survival of salmon. The video details the condition of salmon and the causes of decline. Most of the commentary and examples are from Northern California. 1995. 60 minutes. A Terra Video production that is available by calling (800) 333-4350.

Fresh Waters Flowing

Explores the connection between humans and streams, revealing the links between human influences and the ability of a stream to support healthy biological communities. 1998, 20 minutes, $16, Adopt-a-Stream Foundation (425-316-8592)

Life Cycle of the Salmon

Captures the remarkable life story of the salmon with memorable images that reveal the salmon's world, often from their underwater point of view. 1999, 6 minutes, $10, Oregon Sea Grant (800-375-9360)

Return of the Salmon

Describes the status of salmon, their reliance on healthy watersheds, the historic causes of the current decline, and recent efforts to restore the fish to their native streams. 1995, 33 minutes, $25, Oregon Sea Grant (800-375-9360)

Salmon, Restoring the Legacy

A good overview of the issues at stake in salmon recovery under the Endangered Species Act. Video, 2000, 16 minutes, available by e-mailing rob.bingham@ci.seattle.wa.us or calling 1-877-SALMON -9

Music

"*Chinook Blues*" by Alice De Micele on her album, *Demons and Angels*. Tells the first-person story of the hazards faced by a migrating Chinook Salmon.

"*Come Blow Your Horn*" by Tom Chapin on his album *This Pretty Planet* — A great song about every species' inherent worth.

"*Have to Have a Habitat*" by Bill Oliver (1982) A favorite. This is an environmental classic!

"*The Web of Life*" by Walkin' Jim Stoltz Wild Wind Records
PO Box 160477 or #10 Aspen Court, Big Sky, MT 59716, 406-995-4906. e-mail: walkinjim@walkinjim.com

"*Science Songs*": Includes *Food Chain Gang*, *Decomposers*, and other earth, physical, and life science songs. Order from: www.songsforteaching.com/Hood.html

"*Unintended Consequences*" Eleven songs about household hazardous waste, groundwater, toxins, etc. Titles include: "Storm Drain Stenciling," "Excuse Me, Sir, That's My Acquifer," "We're All Connected," and "Shoppin' for a Better World," and many others. Includes eight panel foldout with all lyrics, $15 each. On CD; order from www.stanslaughter.com/curriculumres/ecomusic.html#intunemusic

Books

Note: All of the books listed are available at amazon.com. Many are available in paperback and can be purchased new or used.

Salmon Stream (Sharing Nature With Children Book) by Carol Reed-Jones; Michael S. Maydak, Illustrator. The book follows a salmon through its life, surrounding it vividly with forest, stream, ocean, and animals. Dawn Publications, 2001. ISBN 1584690135.

Swimmer by Shelley Gill; Shannon Cartwright, Illustrator. The Story of "Swimmer," a chinook salmon, who journeys 10,000 miles to complete her life cycle. Paws IV Publishing, 1995. ISBN 0934007233.

Salmon by Sylvia M. James; Paul Bachem, Illustrator. Mondo Publications, 2000. ISBN 1572558059.

Discovering Salmon by Nancy Field, Sally Machlis. Dog Eared Publications, 2003. ISBN 0941042057.

A Salmon for Simon by Betty Waterton, Ann Blades. A boy named Simon discovers the beauty of salmon as he tries to return a stranded salmon to the ocean. Groundwood Books, 1996. ISBN 0888992653.

Salmon Forest by David T. Suzuki and Sarah Ellis. A young girl, with help from her father, discovers how the forest and salmon need each other. Greystone Books, 2003. ISBN 1550549375.

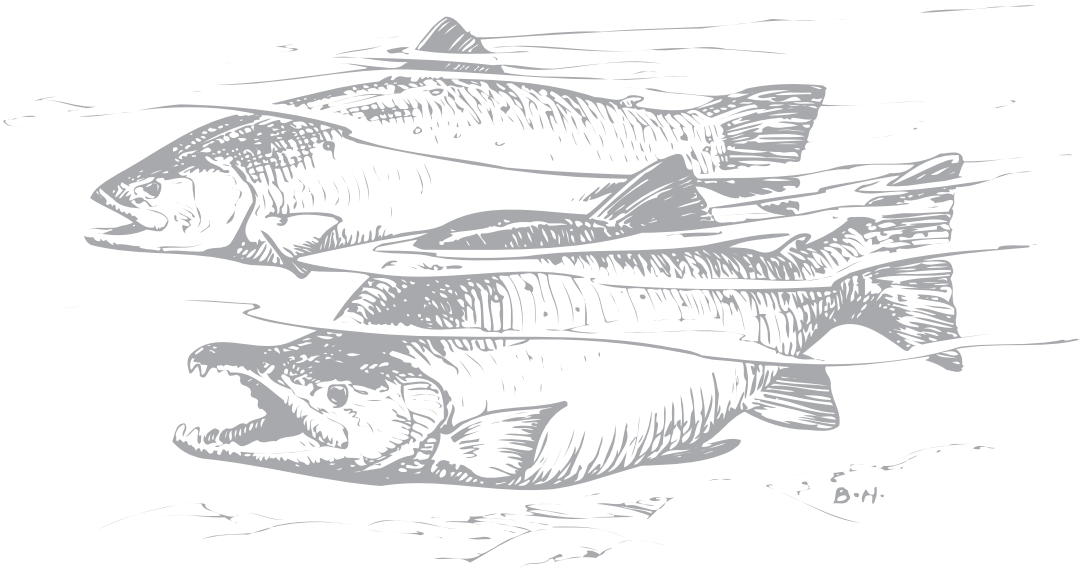
Come Back Salmon by Molly Cone; photographs by Sidney Wheelwright. The story of how an elementary school in Washington state adopted a polluted stream that was once a spawning ground for salmon. Sierra Club Books for Children, 1994. ISBN 0871564890.

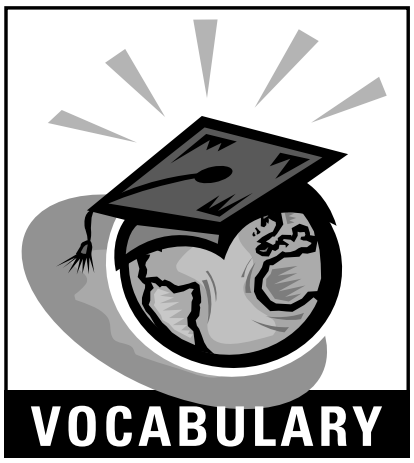
Return to the River by Roderick L. Haig-Brown. *Return to the River* is the story of a Chinook salmon told in novel form. The salmon is the main character in this unique natural history that follows one fish through her entire life cycle. Written in 1941, this book is a true classic. Globe Pequot Press (The Lyons Press, Falcon), 1997. Paperback. ISBN: 1558215816

SPLASH!
Stormwater Pollution: Learn and Share

Salmon and the Ecosystem: Activities

Student and Teacher Handouts





Activity 1

Student Handout "A"

Salmon Sentences

Instructions:

Read **Activity 1, Student Handout B**, "The Facts About Chinook Salmon." Find the following twelve words (or a derivative of the word) in the text. Using a dictionary or the internet, find the meanings of the words. In the space provided, write the meaning of the word and construct sentence using the word. *Make sure the the sentence makes a reference to salmon.*

1. keystone species	**5. nutrient**	**9. stock**
2. anadromous	**6. biomass**	**10. riparian**
3. spawn	**7. endangered**	**11. pesticide**
4. estuary	**8. extinct**	**12. olfactory**

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SPLASH!
Stormwater Pollution: Learn and Share

The Facts About Chinook Salmon!

Activity 1

Student Handout "B"

Other salmon factoids:

- Salmon evolved with the glaciers
- Each species seeks out different spawning and rearing habitats:

  Silvers - small tributaries
  Chum - lower stretches of river
  Pinks - lower stretches of river
  Sockeye - rivers with lakes
  Kings - fast or long, high volume rivers
  All species - tend to time their journey up the rivers so as not to co-opt other species.
- Salmon once ran in all rivers of Northern Europe from Iceland to Portugal (including British Isles and Scandinavia).
- Europeans were salmon-dependent 25,000 years ago — salmon was the main food source.
- In the middle ages, salmon were so abundant that apprentice contracts had clauses stating the apprentice would only have to eat salmon once or twice a week.
- European salmon are like our steelhead in that they can spawn more than once.
- One hundred years ago, the estimated **biomass** of salmon returning to spawn in the Northwest was 500 million pounds. Today, dwindling salmon **stocks** resulted in a reduction of biomass by 93% to 97%.

DID YOU KNOW? Chinook salmon is an **anadromous** species of fish that spend between 1-8 years in the ocean before returning to their natal streams to spawn, though the average is 3-4 years.

SCIENTIFIC NAME: *Oncorhynchus tshawytscha*, from the Greek words onkos (hook), rynchos (nose) Male and tshawytscha (the common name for the species in Siberia and Alaska). Common names include: King salmon, tyee salmon, Columbia River salmon, black salmon, chub salmon, hook bill salmon, winter salmon and blackmouth.

DESCRIPTION: The chinook salmon is blue-green on the back and top of the head with silvery sides and white bellies; black spots on the upper half of its body with gray/black mouth coloration. Chinook grow up to 58 inches in length and weigh up to 129 pounds; although they are generally up to 36 inches in length and weigh up to 30 pounds.

LIFE CYCLE: Spawning in streams that are larger and deeper than other salmon utilize, chinook salmon **spawn** from late summer to late fall, depending on the run. Fry and smolts usually stay in freshwater from 1-18 months before travelling downstream to estuaries, where they remain up to 189 days. Chinook salmon spend 1-8 years at sea before returning to birth streams to spawn. It is widely believed salmon use **olfactory** cues to find their way back to their natal streams.

RANGE: Chinook salmon range from Kotzebue Sound, Alaska, to Santa Barbara, California. Spawning and rearing chinook are found in most of the rivers in this region, with significant runs in the Columbia River, Rogue River, and Puget Sound.

HABITAT AND ECOLOGY: Freshwater streams and **estuaries** provide important habitat for chinook salmon. They feed on terrestrial and aquatic insects, amphipods, and other crustaceans while young, and primarily on other fish when older. Eggs are laid in deeper water with larger gravel, and need cool water and good water flow (to supply oxygen) to survive. Mortality of chinook salmon in the early life stages is usually high due to natural predation and human induced changes in habitat, such as siltation, high water temperatures, low oxygen conditions, exposure to **pesticides**, loss of **riparian** stream cover and reductions in river flow. Estuaries and their associated wetlands provide vital nursery and feeding areas for the chinook prior to its departure to the open ocean. The draining and filling of wetlands and the pollution of the estuary from industrial discharges and stormwater run-off negatively impact chinook salmon.

ECONOMIC VALUE: Chinook salmon is highly valued by commercial fishermen despite their scarcity relative to other Pacific salmon along most of the Pacific coast. Chinook salmon is also an important subsistence fish and a valuable recreational resource.

Other salmon factoids:

- All Pacific salmon, except steelhead (Korea to northern California) die after spawning.
- Native peoples from the Ainu people in Japan to the Klamath people on our continent and most all indigenous people in between welcomed the first salmon ceremoniously.
- Many native peoples believed salmon were people who gave their salmon disguises as gifts to the land people in gratitude for their respectful treatment.
- Each species of salmon has a different "burst" speed and one culvert might be passable to Kings but not to Chums.
- Some salmon leap better than others. Chum don't like to jump.
- Chum fry don't hang around their birth streams very long; Silvers hang around for about one year.
- Some salmon stay in the gravel for 180 days depending upon oxygen content and water temperature.
- Some salmon run up to 1,000 miles inland.
- The Irish believed in a salmon of wisdom who when caught and eaten bestowed wisdom on the diner.
- What is the oldest known age of salmon and steelhead (in completed years)?

  Pacific salmon: 7
  chinook: 7
  sockeye: 7
  silver: 4
  chum: 6
  pink: 2
  Atlantic salmon: 8
  steelhead trout: 8

- Today, 27 stocks of wild salmon are **extinct**; many other stocks are in danger.

Interesting questions about salmon:

What is the oldest known salmon fossil?

The oldest verified fossil for a freshwater version of the salmon is 50 million years old. Five to six million years ago salmon had fangs, weighed over 500 pounds, and were ten feet long. The modern Pacific salmon emerged about two million years ago in the cold mountain streams of the Pacific Northwest.

How many eggs do salmon produce?

Generally, salmon species produce from 2,500 to 7,000 eggs depending on species and size of the fish. Chinook generally produce the greatest number and largest eggs.

How many species of animals depend on salmon?

According to the Washington State's Department of Fish and Wildlife, 137 species of animals — from tiny midges to five-ton killer whales — depend on salmon. Several threatened or **endangered** species — including the grizzly bear, the marbled murrelet, the gray wolf and the bald eagle — are on the list. Salmon are considered to be a keystone species inthe northwest ecosystem, helping to support the entire ecosystem of which they are a part.

Why do Pacific salmon die after they spawn?

Dying salmon improve the chances of survival for their offspring. As the adults die, their carcasses sink, wash up on lakeshores, wash downstream, or are dragged into the forest by bears where they are eaten or left to rot. Each dead salmon contains protein and fat that provides nourishment for fungi, insects, juvenile fishes, mammals and birds. As they decompose, the salmon also fertilize lakes and forests with many minerals and nutrients, which contribute to the food chain that supports their young the following spring. They also provide a huge feast for grizzly bears, black bears, bald eagles, and stoneflies.

Where and why do baby salmon hitch a ride on a barge?

Since 1976, baby salmon have been carried by barges and trucks around the Snake River dams at great expense by the U.S. Army Corps of Engineers. This has never resulted in an adequate number of adult salmon returning to spawn to meet federal recovery goals.

Salmon Homing Instincts

Activity 2

Teacher's Instructions

Developed by the Pacific Science Center and modified by Deborah A. Werner, St. Catherine School, Seattle, Washington

This activity is appropriate for grades 5-8.

Time Needed:

Approximately 90 minutes

Overview:

In studying the life cycle of salmon, students are most curious about how salmon can find their way back to the stream in which they were hatched. They are especially amazed that some species can find their home stream after being out in the open ocean as many as six years.

Scientists have conducted research in this area, and it seems almost certain that salmon use the smell of the water to find their home stream.

Purpose:

In this activity, students can experience first-hand what it is like to be a returning salmon attempting to find its home by smell. This activity provides an opportunity for the entire class to participate in the life cycle of the Pacific salmon and experience the hazards of their journey.

Objectives:

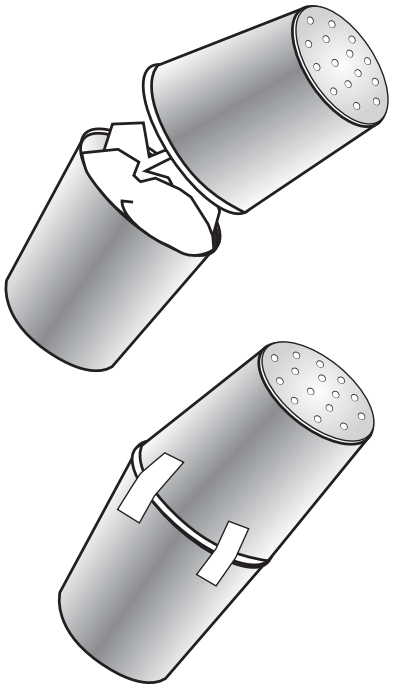
Students will be able to:

1. Experience first hand what it would be like to be a returning salmon attempting to identify a home stream by smell.
2. List hazards that a salmon encounters in its journey to sea and back to its home stream.
3. Identify the stages of the salmon life cycle.

Resources/Materials needed:

In setting up this activity, the following are needed:

- Styrofoam cups or recycled film canisters
- Masking tape
- Pencil
- Paper towels or cotton balls
- Jump rope
- Name tags
- An assortment of smells (i.e. cloves, vanilla, peppermint, etc.). It is best to use smells that the students can't easily identify, so you can mix the scents.



Creating the "Streams"

To construct the salmon's home stream, crumple a paper towel or cotton balls and sprinkle a smell on them. Stuff the scented paper towel into one end of the cup that has holes punched in the bottom. (Film canisters work well too.) Invert the a second cup over the cup containing the scented material and tape them together. Write the name of a stream on the bottom of the cup without the holes. You will probably want to construct 5-6 streams. As you assemble these, avoid any visual differences.

Activities:

1. Punch holes as uniformly as possible in the bottom of the cups or film canisters and place them around the room. Stuff them with scented paper towels or cotton balls. (See illustration.) Assign names tags to the students to match them with their home stream. As juvenile salmon, let students become acquainted by smell with their streams.
2. Have them identify their stream by looking on the bottom of the cup. Locate the streams on a state map and discuss any limiting factors they might encounter. (Example: Assign students to streams associated with Oregon rivers that support salmon runs. The Siuslaw, Umpqua, Columbia, McKenzie, Willamatte, Sandy, etc. are good examples.)
3. Send the salmon out to sea to feed and grow. While the salmon are feeding, change all the stream positions. As small feeding salmon, they encounter many hazards enroute. They could get caught in turbines. This could be simulated by having them run through a rope being turned. If caught, they are eliminated. Or, feeding salmon could be caught in gill nets or by other predators. This can be done by having extra students be "fisherman" or "predators" and draw numbers for the fish they will take. In their journey home, they might encounter impassible fish ladders or high dams. To represent this place several streams on a high shelf or block the way. Then call all of the surviving salmon back to locate their stream. When they feel they have identified their stream, let them check the name.
4. With a new group of salmon, proceed with the above mentioned activities, but alter the stream(s) by polluting it. You can spray room deodorant on the cup, both heavily and lightly. Be sure to leave one or two streams unpolluted. Mix the positions of the streams again. It will be difficult for them to identify the heavily polluted streams.

Tying it all together:

As you can see, this activity lends itself to many options and ideas. You can make it simple or more complex. Students are actively involved and are very enthusiastic throughout the activity. They begin to realize a few of the problems of being a Pacific salmon.

Adapted through the source of "Sniffin' Salmon" by Dr. Richard Dudley, Fisheries Biologists, Oregon State University and Bill Hastie, Marine Consultant, Oregon Department of Education.

Salmon Survival: Choices and Consequences

Activity 3

Teacher's Instructions

In this exercise, students are asked to play the role of a stakeholder and make decisions regarding issues that can affect water quality. The decisions they make can have negative or positive consequences for salmon. This exercise has been developed for students in grades 6-8.

Amount of Time Needed:

Approximately two hours.

Instructions:

Divide class into groups of equal numbers (Four or five per group works well.) Arrange tables or desks so each group can discuss issues. Have each student in the group take a turn as moderator for a question. Give each group a copy of Salmon Survival "Student Handout A."

For each question, have the groups come to a consensus regarding the action to take on the issues presented. The moderator should keep track of the action chosen for each situation. After all of the questions have been discussed, give students "Student Handout B" which shows points assigned for each decision. Have each group create a graph (graph sheet provided) to chart their points and let them see whether their choices are "salmon friendly" or harmful to salmon and their habitat.

Salmon Survival: Choices and Consequences

Activity 3

Student Handout "A"

For each question, discuss the issue and choose an action to take on each issue. Choose a moderator to keep track of the action chosen for each situation. After each question, write down your choice and a brief explanation of why your group made that choice in the space provided. After all of the questions have been discussed, use Handout "B" to score your answers. Use the graph provided to chart your points and see whether your choices are "salmon friendly" or harmful to salmon and their habitat.

Question #1

Stakeholder: Manager of a local shopping mall

Issue: After 30 years, the landscaping in the local mall parking areas has become overgrown. The parking area has approximately 30 storm drains that that carry runoff directly to a nearby river. The manager has come up with three plans to consider. Which plan should they choose?

1. Remove all of the old plants and bark-o-mulch the planting areas.

2. Replace the plants with native trees and shrubs.

3. Tear out the landscaped areas and add pavement to make room for more parking.

Choice: # _____

Explain your choice: _____

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Question #2

Stakeholder: Local developer

Issue: A new subdivision is being built near the headwaters of a local creek. Because all of the runoff from the roofs, streets, and driveways will be carried through the storm drains directly to the creek, the developer would like to include some type of stormwater treatment feature in the subdivision. Cost is an issue. Here are some possibilities:

1. Creat a natural swale and above-ground retention pond to collect and filter stormwater before it flows to the creek. Landscape the pond with the same native plants found in the vicinity. Although this is an excellent way to treat stormwater, it will mean sacrificing one or two building lots, resulting in less profit. However, the natural feature may attract buyers who appreciate nature.

2. Include an underground detention tank that collects and filters stormwater before it is released into the creek. This system is not natural and not as effective as a swale and pond. Although this is not inexpensive, it does not take up above-ground space and allows homes to be built on all of the lots available, resulting in more profit for the developer.

3. After studying the options, the developer decides a stormwater treatment feature will not be financially feasible. Although they regret not being able to treat the runoff, they are concerned about their financial return on the original land investment.

Choice: # _____

Explain your choice: _____

_____

_____

Question #3

Stakeholder: You

Issue: A new house is being built in your neighborhood. You have noticed lots of dirt from the construction site is being washed into the street by the rain. The construction trucks are also leaving a trail of mud from their tires when they leave the site. The storm drain in the street is getting clogged with all of this dirt. What do you do?

1. Do nothing. The rain will clean the street by washing all of the dirt down the storm drain.

2. Worry about it a little bit. Even though you know the dirt goes down the storm drain and is carried directly to the river, you figure the river has dirt in it anyway, so a little more won't hurt.

3. Ask your parents or teacher to call the local Public Works Department and find out if the building contractors can do anything to stop the erosion and keep the street clean.

Choice: # _____

Explain your choice: _____

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Question #4

Stakeholder: You

Issue: Your dadand mom like big, lush, green lawns. Lately, some areas of the lawn are turning brown. Your parents suspect crane flies are killing the lawn and want to put diazinon, a pesticide, on the lawn to kill the crane fly larvae.

1. Help put diazinon on the lawn. Put some extra on the brown spots. You don't like the idea of insects killing the grass either!

2. Read the instructions on the package with your parents and follow them. Use only as much as you need.

3. Ask your dad or mom to call a local nursery to find out if there is a more natural way to control crane flies and other lawn pests.

Choice: # _____

Explain your choice: _____

_____

_____

Question #5

Stakeholder: You

Issue: You have talked your parents into replacing some areas of lawn with native shrubs and trees. However, you are still in charge of mowing the remaining areas of lawn. What will you do with the grass clippings?

1. Put the clippings in a wheel barrow and dump them in the big ditch down the street.

2. Mow the lawn more often and leave a thin layer of clippings on top of the lawn.

3. Collect the clippings and compost them in a corner of the back yard. Use the compost in your planting beds and vegetable garden.

Choice: # _____

Explain your choice: _____

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Question #6

Stakeholder: A local timber company owner

Issue: You have purchased private land with large second growth trees. The land is part of a watershed that has a major stream with salmon spawning grounds and some smaller feeder streams. To make a maximum profit, you plan to log all of the land, including the trees alongside the smaller streams. You could leave some trees along the small streams, but don't think it would make a difference. You also only want to replant the logged areas with the minimum number of trees required. What do you do?

1. Log all of the trees. The little streams aren't that important.

2. Leave a one-tree wide buffer along the smaller streams. Replant the logged areas.

3. Leave a wide buffer along all the streams and replant the logged areas with extra trees.

Choice: # _____

Explain your choice: _____

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SPLASH!
Stormwater Pollution: Learn and Share

Activity 3

Student Handout "B"

Salmon Survival: Choices and Consequences Answer Sheet

Question 1:

Stakeholder: Manager of a local shopping mall

Issue: After 30 years, the landscaping in the parking areas at a local mall has become overgrown. The parking area has approximately 30 storm drains that carry runoff directly to a nearby river. The manager at the mall has come up with three plans to consider. Which plan would you choose?:

Consequences:

1. By replacing the plants with bark-o-mulch, you will increase the amount of stormwater runoff and risk the chance of flooding in parking areas. (Plant roots soak up rainwater, reducing the amount of water that runs into the storm drains.) Exposed bark-o-mulch can be washed by heavy rains from the landscaped areas and large amounts can clog storm drains causing flooding. The loss of shade from trees also allows rainwater to heat up when the sun comes out. Heated water entering the river can harm fish and aquatic organisms -2

2. This is the wisest choice. Native plants will thrive with little care and are resistant to bugs and disease. This reduces the amount of labor time needed to maintain the plants and eliminates the use of harmful chemicals that can be carried with stormwater to the river. The plants also soak up rainwater which reduces runoff. This choice not only saves money, but also helps improve water quality. +3

3. Adding even more impervious surface dramatically increases polluted, heated runoff. -3

SCORE: _____

Question 2:

Stakeholder: Local developer

Issue: A new subdivision is being built near the headwaters of a local creek. Because all of the runoff from the streets and driveways will be carried through the storm drains directly to the creek, the developer would like to include some type of stormwater treatment feature in the subdivision. Cost is an issue.

Consequences:

1. This would be a win-win situation for people and the environment. Cleaner water would be entering the creek and the cost the community pays to clean up polluted water would be reduced. Aquatic habitats would be preserved and support more species. The developer would win too; the lots may sell for a higher price to people who are willing to pay a little more for a clean environment. The only negative aspect of this plan would be the reduction of buildable land within the urban growth boundary. +3

2. This is a good solution and will help reduce pollution in the creek. However, there is a trade-off; putting the tanks underground will allow more homes to be built resulting in more impervious surface and more runoff. +1

3. Not providing any treatment for stormwater runoff would be disastrous for the creek. It would also result in lots of bad publicity and could hurt the developer's reputation in the community. -3

SCORE: _____

Question 3:

Stakeholder: You

Issue: A new house is being built in your neighborhood. You have noticed lots of dirt from the construction site is being washed into the street by the rain. The construction trucks are also leaving a trail of dirt from their tires when they leave the site. The storm drain in the street is getting clogged with all of this dirt. What do you do?

Consequences:

1. Salmon build nests in the gravel bottoms of local creeks and streams. Dirt and silt that make their way to local waterways through the storm drain system will clog the gravel bottoms of creeks and rivers. This adds up to habitat destruction for salmon. With fewer places to build spawning nests, fewer salmon survive. -3

2. You need to worry more! Not only does all of this dirt ruin spawning areas, it can also clog the gills of young fish, depriving them of oxygen. -3

3. You are a responsible young citizen who cares about salmon! The Eugene Public Works Department has erosion specialists who will work with developers to help them reduce erosion from their building sites. +3

SCORE: _____

Question 4:

Stakeholder: You

Issue: Your dad likes big, lush, green lawns. Lately, some areas of the lawn are turning brown. Your dad suspects crane flies are killing the lawn and wants to put diazinon, a pesticide, on the lawn to kill the crane fly larvae.

Consequences:

1. Diazinon doesn't just kill crane fly larvae, it also kills worms and the birds that eat those larvae! It also does not work on adults crane flies. Applying more than is needed is always a bad idea; the extra diazinon will get washed down the storm drain when it rains or you turn on the sprinklers. The diazinon can also hurt salmon. Salmon depend on their sense of smell to migrate back to their homestreams to spawn. They also can smell predators. Scientists have discovered diazinon, found in even small amounts in rivers or the ocean, can destroy the sense of smell in salmon. This can cause a disaster in salmon populations. They can't find their way home and are more likely to be eaten by predators! -3

2. This is more reponsible, but there are better ways to keep your lawn healthy. -2

3. Much better choice. There are natural products that will not harm the environment. Garden stores carry products that will control crane flies but not harm birds, children, or pets. Parasitic nematodes will also help control crane fly infestations in your lawn. Aerating your lawn, raking up extra thatch, and attracting birds to your yard will help control crane flies. Another option would be to dig up some of your lawn and plant native plants that thrive on less water and are resistant to pests. +3

SCORE: _____

Question 5:

Stakeholder: You

Issue: You have talked your dad into replacing some areas of lawn with native shrubs and trees. However, you are still in charge of mowing the remaining areas of lawn. What will you do with the grass clippings?

Consequences:

1. Not a good choice. During heavy rains, the ditch carries excess rain water to the nearby creek. The lawn clippings will be carried along with the rainwater to the creek. As the lawn clippings decompose in the stream, they use up oxygen that salmon and aquatic organisms need to survive. -3

2. This is a better choice. The clippings will help retain water, reducing the need to use lots of water to keep the lawn green. As they decompose, they help fertilize too. +3

3. Another good choice. Recycling lawn clippings is good for the environment. Using the compost as a natural fertilizer reduces the need for chemical fertilizer and saves money. +3

SCORE: _____

Question 6:

Stakeholder: A local timber company owner

Issue: You have purchased private land with large second growth trees. The land is part of a watershed that has a major stream with salmon spawning grounds and some smaller feeder streams. To make a maximum profit, you plan to log all of the land, including the trees alongside the smaller streams. You could leave some trees along the small streams, but don't think it would make a difference. You also only want to replant the logged areas with the minimum number of trees required. What do you do?

Consequences:

1. The small streams are important! In a watershed, smaller streams flow into the main stream. Logging all of the trees along the small streams increases erosion. Dirt and debris from erosion will be carried from the small streams into the main stream. Removing the trees also exposes the water in smaller streams to the hot sun, increasing water temperature. Salmon need cool, clean water in order to spawn and survive. Silt, debris and increased water temperatures will combine to destroy the salmon habitat. -3

2. This is better, but not good enough. A one-tree buffer won't stop the erosion and will provide only a little shade during part of the day. And, replanting with only the minimum amount of trees may not replace all of the trees that were logged since some of the transplants will be eaten by wildlife or killed by disease or insects.-3

3. Although not as profitable, this is an environmentally responsible choice. +3

How did you score?

Chart your points for each question on the chart provided. The more positive choices you make, the greater the chance for salmon survival.

SCORE: _____

ACTIVITY 3: Student Handout "C"

Issues and Consequences: Chart your points and see how your choices impact salmon survival

SPLASH!
Stormwater Pollution: Learn and Share

Stormwater Pollution Match-up Game

Activity 4

Teacher's Instructions

This game will teach students how common pollutants that make their way onto local waterways can harm salmon during specific stages of their life cycle.

Time Needed:

Approximately one hour.

Instructions:

Divide students into groups of four or five. For each group, place cards depicting the stages of the salmon life cycle and the cards showing pollutants face up (pictures up) on a table. Have students match a pollutant card with a life cycle card. When each life cycle card has a pollutant card matched with it, have students turn over the life cyle card to see if they have correct choices. If they have incorrectly matched the cards, have them try again and until all of the correct matches are made. Once the cards are all correctly matched, have the students turn over the pollutant cards and read information about where the pollutants originate.

After playing the game, ask students if they have seen any of these pollutants in their neighborhoods or their home. Have the entire class brainstorm ways to keep these pollutants out of local waterways.

Extensions:

Distribute and discuss three additional handouts: *Salmon Decline Affects Everyone*, *The Facts about Chinook Salmon*, and *Salmon Through the Ages*.

SPLASH!
Stormwater Pollution: Learn and Share

Activity 5

Student handout

Salmon and Sitka Spruce:

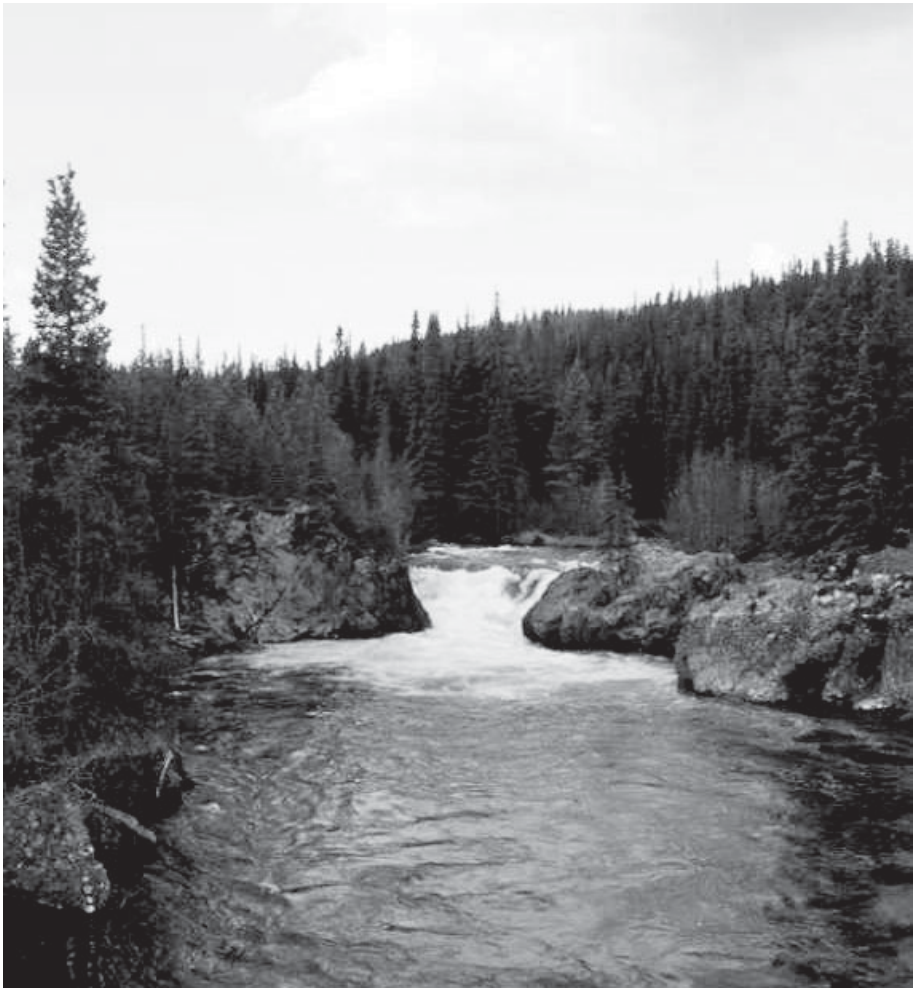
A Mutually Dependent Relationship

Students: After reading the following article, answer the questions on the back page.
Teachers: Lead a class discussion allowing students to compare answers to each question use the discussion as a basis to explore the relationship between species.

The relationship between the salmon and the forest is intriguing and complex. Many studies have been conducted to explore how the presence of spawning salmon influences the health of streams and the adjacent riparian areas. Although it is known that the marine-derived nutrients from the decaying bodies of spawned-out salmon are spread throughout the stream and surrounding riparian areas, how much does this natural fertilizer effect tree growth along stream banks? In one case, the results were quite surprising.

In a study done on two streams in Alaska, researchers discovered a significant difference in the growth rates between Sitka spruce trees that grow along streams where salmon spawned and trees upstream from spawning areas (Helfield and Naiman 2001). These two streams support dense runs of pink salmon and smaller runs of coho and chum salmon. The study found that spruce trees along spawning sites had a growth rate that was more than three times faster than spruce trees in upstream areas not influenced by salmon. The conclusion was that the decaying bodies of spawned-out salmon provided tremendous amounts of nutrients that contributed to the accelerated growth of the spruce trees.

The relationship between the salmon and the spruce tree is not just a one way street. The larger spruce trees have a very positive impact on the stream habitat necessary for salmon survival.



Sitka spruce along an Alaskan stream

Larger trees provide more shade, which helps moderate water temperatures, creating ideal conditions for salmon reproduction. The larger root systems of the spruce trees stabilize stream banks and filter sediment, reducing erosion into the stream, which increases the rate of survival of salmon embryos. Leaf litter from the trees falls into the stream, providing organic nutrients for insects that are an essential part of the juvenile salmon's diet. Stream habitat is also enhanced by fallen trees. Large woody debris in streams helps moderate flow, protecting salmon embryos and fry from being washed downstream by high winter flows. Downed trees also trap sediment, keeping spawning beds free of silt that can suffocate developing embryos. Again, larger trees make a difference. Due to the increased heights of the spruce trees, even trees farther away reach the stream banks when they fall.

The mutually dependent relationship between the salmon and these Sitka spruce trees has evolved over millions of years. Traditionally, fisheries management has focused on a single-species model where salmon were regarded only as a commercial resource. This model ignored the relationship between salmon and their ecosystem. The realization that salmon is the keystone species in a complex ecosystem is a fairly recent discovery. As people learn and understand more about salmon and forests, new management strategies can be developed to ensure the survival of wild salmon.

Bibliography

Helfield, J. M. and R. J. Naiman. 2001. "Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity." Ecology 82: 2403-2409.

Questions for discussion:

1. After reading about the mutually dependent relationship between the Sitka spruce and salmon, can you think of any other species that have a dependent relationship with salmon?

2. Can you think of any other similar dependent relationships between species? Describe how the relationship works.

3. In a dependent relationship between species, what happens when one species is removed or no longer a factor?

The Salmon Food Chain and Food Web

Activity 6

Teacher's Instructions

Activity 6, Part 1: The Salmon Food Chain

This exercise will help students understand how nutrients and energy are passed through the "food chain" and how many food chains can be integrated to create "food webs."

Before beginning the exercise, provide students with the color handout, *Salmon, The Food Chain and Food Web*. Review the handout and discuss the salmon food chain and food web. After discussing the handout, begin the activity.

Materials Needed:

Ball of String
Nametags (provided)

1.Assign students to be elements and organisms in the salmon food chain using the name tags provided. Elements and organisms included:

Sun
Phytoplankton
Zooplankton
Squid
Salmon
Killer whale

Create a simple food chain:

Using six students, hand out nametags depicting the species that are part of a simple salmon food chain. Starting with the sun, have students form a chain. Using a ball of string, connect the food chain by passing the ball to each member and having them hold onto the string with one hand. To create "stress" within a food chain, have students pull on the string until it breaks. Ask the students the following questions. What link was broken? How will the break affect the rest of the food chain? Repeat the activity until all students have had a chance to participate.

Activity 6, Part 2:
The Salmon Food Web

Adapted from an activity developed by the Vancouver Aquarium Maine Science Center, Vancouver, British Columbia.

To discover how important salmon are to the Northwest ecosystem, change the **Food Chain** exercise to make salmon the central species in a **Food Web**. Divide the class into groups so all students can participate.

Materials needed:

String
Nametags (provided)

1. Assign students to be biotic and abiotic elements in the salmon ecosystem using the name tags provided. Elements include:

sun	air	water
bear	mayfly	tree
log	frog	eagle
mosquito	fish	salmon
fungus	stream	plankton

2. Assign the "salmon" to stand in the middle of an open area. Give the salmon a piece of string and have them name something they need to survive. Give the other end of the string to the student wearing that nametag. That student will then name something they need to survive or something that relies on their element for survival and join strings with that student. (Be sure students choose the elements listed above.) Continue until all of the students are connected in some way.

Introduce human activities that could harm the ecosystem. Brainstorm with students to create a list of other factors that could be harmful. Examples include road building along a stream, chemical pollutants and fertilizer carried into a waterway with stormwater, and heated water from industrial discharge. Which elements or organisms in the food web would be affected by each of these factors? After identifying harmful factors, remove the element or organism that is impacted. How does this weaken the food web?

Examples:

1. Road building removes trees and adds silt from erosion to the stream. Increased sunlight from the loss of trees raises water temperature, which increases the incidence of disease in salmon. Silt smothers salmon eggs and ruins spawning areas. The stream and the salmon would be impacted.

2. Chemical pollutants can reduce growth rates in young salmon; some chemicals can kill juvenile and adult salmon. Pollutants also kill the aquatic insects young salmon depend on for food. The mayfly, frog, fish, and salmon would be impacted.

3. Fertilizer introduces nitrogen into the waterways, which causes large algae blooms (excess growth of algae). As the algae dies and decays, it uses up oxygen, leaving little for aquatic organism and fish. The mayfly, frog, fish, and salmon would be directly impacted.

4. Heated water from industrial discharge raises water temperatures. Salmon will only spawn in cool water. The stream, mayfly, fish, frogs, and salmon would be directly impacted.

Extension of Food Web Exercise:

Scientists have found ocean elements (nitrogen and carbon isotopes) far inside inland forests. These elements, carried from the ocean by salmon, have been found in trees, insects and soil.

To simulate how these elements are carried from the ocean to the inland forest, have students pass an element up the food chain from ocean to a forest organism. (Use an object from the classroom that can easily be passed from student to student.) Make sure the object is passed along to a tree or fungus. Have students brainstorm to determine how the element entered the tree or fungus. An example might be: an animal that feeds on salmon dies near the tree and decomposes. The organic matter acts as fertilizer for the tree; nutrients and the ocean elements are absorbed by the trees roots.

Questions:

How important is the salmon in the food chain (or web)?

How is the food chain (or web) impacted by the loss of salmon?

Can any other species replace the salmon in the food chain (or web)?

Wild Chinook in the Northwest

Salmon Through the Ages

Proud boy and Chinook salmon, Columbia River, 1917.

Wild salmon once filled the rivers of the Pacific Northwest. Since the ice ages, this muscular fish has embodied the health and vitality of this region. Prior to European settlement in the Northwest, salmon were an important food staple for some local tribes and the heart of many Native American tribes' culture and heritage.

When Lewis and Clark were exploring the Columbia and Snake River basins in 1805, they reported Indians catching massive quantities of salmon, 10 - 16 million fish by current estimates. Sixty years later, the first salmon cannery in North America was established near Astoria, marking the first of commercial salmon harvests. By the early 1900's, it was estimated that 30 million wild salmon and sea-run trout came upstream to spawn. Despite weakening salmon stocks from commercial fishing and streamside development, the fishing industry was valued at $1.2 billion annually. By the late1980's, commercial fishing had decreased by 85 percent.

Overfishing, habitat destruction, fish hatcheries, water pollution and large-scale environmental changes have caused salmon runs to decline in the Pacific Northwest.

Since European settlement, 9 out of 10 wild salmon runs and 100 distinct salmon stocks have disappeared from the region. Three times that many are at risk of disappearing and losing their habitat.

"Salmon are the soul of the Pacific Northwest," writes Joe Cone. "In their return upriver to spawn, they are the symbol of the life force of this region." Their declining numbers are an early warning sign that there is much more at stake than just the decline of their population.

Spokane women drying salmon.

Horse seins were used to snare salmon.

Cannery worker and the catch of the day.

Native American fisherman spearing salmon at Celilo Falls, Columbia River.

Assembly line of workers process salmon.

Salmon Decline Affects Everyone

The Pacific Northwest is losing its salmon. Rivers like the Willamette were once braided with numerous side channels that provided ideal spawning grounds and rearing habitat for juvenile salmon. Over time, suitable habitat has been reduced or degraded, threatening salmon populations everywhere.

In Eugene, salmon live in the Willamette River, many of the small streams that flow into the Willamette, and portions of Delta Ponds during one or more stages of their life cycle. Juvenile salmon (fry and smolts) migrate from upstream areas to seek shelter in small alcoves and side channels along the Willamette where they can feed, hide from predators, and grow for up to a year before continuing their journey downstream to the ocean. The cycle continues when returning adult salmon migrate from the ocean through Eugene from May through July, heading back to their "home stream" to spawn.

Why should we be concerned? Healthy salmon populations are a direct indicator of healthy rivers. The preservation of wild salmon is directly related to natural resource protection, growth management and our quality of life. If we do everything we can to protect salmon and salmon habitat now, we can ensure salmon will be abundant in future generations.

Many things we do in our every day lives, from washing our cars to using pesticides in our yards, can have a negative impact on water quality. Only by being aware of how pollution affects salmon and by changing our habits can we help keep water clean and salmon populations healthy. It will take a commitment by citizens, public institutions, and private companies alike if salmon are to survive.

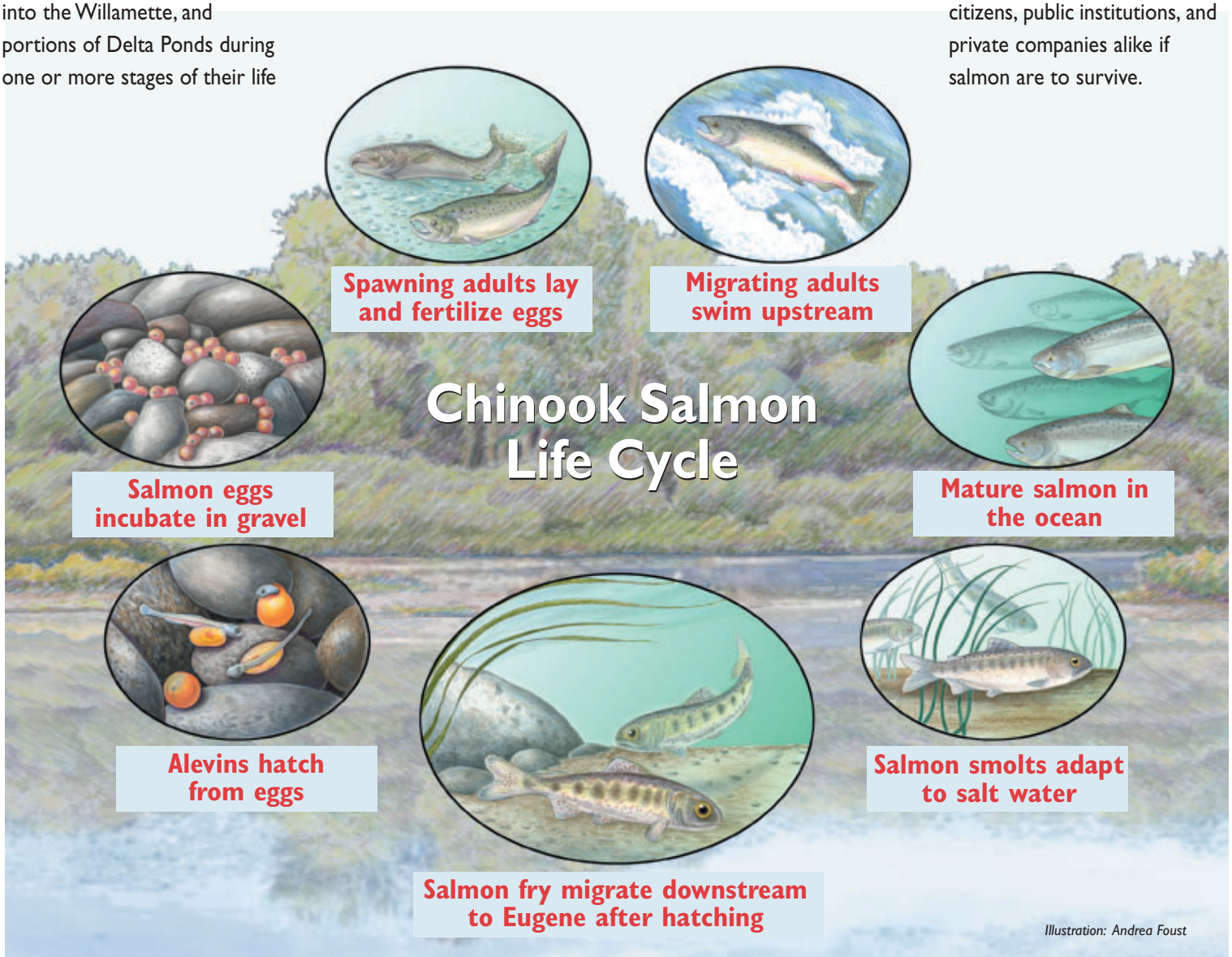


Illustration: Andrea Foust